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Treatment Intensity and Provider Remuneration: Dentists in the British National Health Service[1]

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Abstract

Dental service providers in the British National Health Service (NHS) operate under a number of remuneration arrangements that give rise to different incentives. We present a theoretical model of the effect of different remuneration structures on treatment intensity and test this model on data on treatments carried out in Scotland. After controlling for differences in patient need and dentist specific preferences, we find that self-employed dentists treat patients who are exempt from payment more intensively than their employed counterparts. The results imply that changes in remuneration can have a large effect on the distribution of treatments. More generally our results provide support for economic models that view financial incentives as important determinants of physician behaviour.

JEL classification: I11

Keywords: health services, British NHS, physician agency, treatment intensity, financial incentives.

1 Introduction

A recurring concern in the health care literature is the discretion that providers of health care have over the extent of treatment offered, inputs that affect cost, quality and the price of health care and the extent to which this discretion is exercised in ways that may be against the interests of the recipients of health services or private or public purchasing agencies. McGuire (2000) refers to these related issues as "Physician Agency". When prices are administered, and therefore set outside of the control of physicians, and quality issues are not paramount, physician agency problems persist if the quantity of services delivered differs from that which the patient, or a third party payer – such as an insurance company – would wish to have delivered. If the payer could observe the precise medical condition of a patient and could monitor the treatment carried out, then it would simply be necessary to specify which treatments will be paid for, for which types of patients. In practice, however, it is not possible to specify and monitor the precise medical condition of patients and, thus, providers retain considerable discretion in how they treat individual patients – a given course of treatment can then be justified on the grounds that the patient's particular circumstances warranted it. By making treatments more or less remunerative or by choosing to retain physicians on fixed wage contracts, purchasers may seek to align physician actions with their desired outcomes. Whilst, such instruments can be expected, in a wide variety of circumstances, to affect the prevalence of treatments their impact in practice may be limited by the extent to which medical ethics or other objectives being pursued by physicians offset the impact of financial rewards. Hence, the effectiveness of provider remuneration in influencing outcomes is an empirical question and it is towards resolving that question that this paper is directed.

The absence of natural experiments in which remuneration methods are contemporaneously varied across physicians and the difficulty of controlling for the variation of patients received by individual physicians or idiosyncratic preferences on the part of those physicians all represent considerable obstacles to the empirical resolution of this issue. Our data allow us to address these obstacles.

Dentists in the British National Health Service (NHS) work under a variety of remuneration systems that imply differences in the effective price received for differing treatment courses delivered. In part these differences reflect decisions made by the (government) purchaser, which both contracts with independent practitioners and allows for direct employment of practitioners, and in part they derive from the working arrangements of dentists. Young dentists starting out in practice typically enter into a revenue sharing arrangement with other dentists who are owners of their practices. These revenue sharing arrangements imply that dentists within the same practice may face quite different effective prices for delivering treatments. The existence of a single, integrated payments system recording details of payments and maintaining details of the dentists claiming payments and of the patients that they treat, provides an opportunity to assess the effectiveness of different remuneration methods in controlling quantity setting by physician 'agents'.

Our approach is to set out a theoretical framework for analysing the effect of remuneration systems upon the treatment decisions of dentists and to assess that

framework in the light of data generated by the dental remuneration system in Scotland. Consistent with practice, our theoretical framework allows for a distinction between patients who bear the full cost of their treatment and patients who are insulated from these costs, who we term *exempt*. We summarise the dentist's decision in the form of a single outcome which we term *treatment intensity*, that has an observable analogue – the value of the treatments given. Within the theoretical framework we find that there are grounds for expecting that self-employed dentists will engage in more intensive treatment of patients, particularly when those patients are exempt from payment, and thus immune from the financial implications of that treatment.

Subjecting 14053 observed courses of treatment to analysis in the context of our model we find that there are significant and large differences between the treatments delivered according to the dentist's remuneration method. Controlling for both variations between patients and dentist specific variations, we find that self-employed dentists treat exempt patients more intensively. Furthermore, from within the population of self-employed dentists, it is those who are owners of practices that treat exempt patients the most intensively. Hence, we show that otherwise similar patients receive different treatment according the remuneration structure under which their dentist receives payment.

The theoretical literature that forms the starting point for this paper is that concerning third party purchasing for health services and incentives – Chalkley and Malcomson (2000) and McGuire (2000) provide surveys of this literature. This literature considers how third party payers who are in a position to incorporate incentives into their purchasing arrangements optimally choose those incentives. The emphasis in this literature has been upon cost-quality trade-offs. Our approach is to examine how existing simple remuneration systems will impact on the choice of treatment quantity subject to asymmetric information regarding the characteristics of patients of the type considered by Chalkley and Malcomson (2002). A number of empirical studies have considered how purchasing arrangements affect treatment decisions in practice. The transition from cost-reimbursement to prospective payment in the US Medicare system provided data relevant to this approach and that data has been extensively analysed – see for example Ellis and McGuire (1996) who specifically consider issues arising out of selection effects. Our own empirical strategy with regard to these issues is set out in the labour economics literature – see Rosen and Willis (1979) and Heckman, Tobias and Vytlacil (2000) – and follows the tradition of Lazear (2000) in seeking to quantify incentive effects. The data considered here is, we believe, unique in allowing for comparison of remuneration methods across health care practitioners at a given point in time whilst also permitting controls for patient variation and provider selection.

The paper is organised as follows. The next section is concerned with describing some relevant features of the provision of dental services in the British NHS. Section 3 develops the theoretical model and analyses the decisions made by a dentist under a variety of remuneration methods. Section 4 describes our data, sets out our empirical methodology and presents the empirical results. Section 5 contains concluding remarks.

2 Dentistry in the British NHS

The majority of National Health Service (NHS) primary care dental services[1] in Britain are provided by what is termed the *General Dental Service* (GDS). The details of the institutions that we report here relate to the NHS in Scotland but the organisational structure, remuneration methods and remuneration rates apply equally to the NHS in England and Wales.

An individual requiring treatment under the NHS visits a dentist, who is under an agreement with the GDS to provide NHS treatments, and registers with them for treatment. The costs of treatment are met in part by *Health Boards* which receive government funds in order to meet the dental and medical health care needs of their constituent populations. Unlike other health services supplied by the NHS there is a substantial element of patient cost sharing in dentistry. Unless *exempt* from charges, which can occur for a number of reasons, the patient pays 80% of the 'cost' of their treatment up to a cash limit[2]. Approximately 80% of qualified dentists work as primary care *General Dental Practitioners* (GDPs) in the GDS. These dentists and the treatments that they carry out are the focus of this paper.

GDPs are predominantly self-employed and may work both privately and for the NHS. For NHS work a GDP's remuneration contract specifies both a fee for each treatment administered and a capitation payment for each patient registered. Treatments delivered to a particular patient over a single course of treatment are gathered together into a single *claim*. Hence, a claim is comprised of a number of items of treatment, each of which has a fixed price, delivered to a particular patient covering a treatment episode. Historically fees for each treatment were set so as to be a fair recompense for the time and other inputs required to carry out that treatment. Over time technical progress and productivity changes lead to individual treatment fees becoming distorted relative to their original values. For a time there was active review of treatment fees with a view to restoring parity to time and cost but the last major review was in 1996 since when fees have been allowed to vary in 'real' terms simply being re-based in relation to general prices.

Within self-employed dentists there is a distinction between practice owners, who are referred to as *principals* and the tenants of a practice – termed *associates*. Associates practice dentistry in the premises of principals and have a relationship that is governed be an Associateship Agreement. In principle this agreement could take any form that the parties agree to but in practice almost all agreements follow guidelines formulated by the dentists' professional association. In essence, in return for the use of premises and other services associated with it, the associate pays over a proportion of his or her fees to the principal. Hence, associates are insulated by the principal

[1] Another element of provision are dental hospitals – a part of the NHS *Hospital Dental Service* (HDS) – who treat patients referred to them from primary care dentists and carry out surgical procedures or specialist orthodontic procedures.

[2] As an alternative to this conventional route for treatment, patients may opt to be treated privately or to seek treatment by visiting a clinic run through the NHS *Community Dental Service*. The CDS is a specialist 'safety-net' service designed to provide treatment for those patients who may have difficulty in obtaining treatment directly from a dentist (perhaps because there are no dentists under agreement with GDS in their area), or who would not otherwise seek treatment.

from some costs of the treatments they carry out but in return share their revenues with the principal.

Employed (salaried) GDPs are a relatively recent development and were instituted in order to address a number of perceived deficiencies in dental service provision. A workforce planning document, Sco (2000), reports that health boards may choose to create salaried posts if GDPs in their locality are not accepting NHS registrations or if GDPs are only accepting for treatment those patients exempt from payment or entitled to remission or if there are no GDPs practising in an area. An employed GDP works for a fixed salary and does not receive remuneration proportional to the number or types of treatments she carries out. Importantly for our study, employed GDPs *record* a claim in the same way as self employed GDPs by detailing the precise treatments undertaken. These 'shadow' claims do not give rise to any payment but are recorded alongside fee generating claims. Thus, it is possible to compare and contrast the claims made by employed dentists with those of self-employed principals and/or associates.

3 Theoretical Framework

We consider a supplier of dental services, henceforth dentist, who is remunerated by a single purchaser for delivering treatment to a population of n patients with a specific dental condition[3] over a specified duration of time. Patients can fall into one of two payment categories; exempt patients face no out-of-pocket expenditure for the dental treatment they receive and constitute a fixed proportion ρ_E of all patients; non-exempt patients pay a proportion of the cost of their treatment as determined by the purchaser and are a proportion $(1-\rho_E)$ of all patients. We assume that the dentist receives a benefit $b(t)$ from delivering a treatment of intensity t to both sorts of patients and that the benefit function is differentiable and increasing in t. The cost of treating a patient is assumed to be independent of the patient's payment status and has two components. The first, which we denote by $c(t)$, is the monetary cost of treatment, which includes laboratory fees and materials such as amalgam or anaesthetics. The function $c(t)$ is increasing, differentiable and convex. The second element of cost is the dentist's time, the monetary value of which we denote $\tau(t)w(\phi)$, where the function $\tau(.)$ is differentiable, increasing and convex and reflects the time input, in hours, required to deliver treatment of intensity t and $w(\phi)$ which is increasing and differentiable in ϕ, is the opportunity cost of time to the dentist. The parameter $\phi \in [\underline{\phi}, \overline{\phi}]$ allows for variation between dentists in terms of the value of their time and we assume that ϕ is a drawing from a distribution $g(\phi)$.We normalize such that $t = 0$ constitutes the minimum treatment that can be carried out and assume that the upper bound on treatment is determined by the patient's payment category. We assume that exempt patients, who are insulated from the monetary cost of the treatment they receive, will accept any treatment they are offered whilst non-exempt patients, because they face a proportion of the cost

[3]The generalization of this model to a setting where there is a continuum of dental conditions and thus a corresponding distribution of patient *types* is detailed in Chalkley and Tilley (2002).

of treatment, will not accept[4] treatment in excess of $\bar{t}_N$. Finally, we assume that a dentist has a maximum of T hours available to carry out treatments.

3.1 Dentists' Decisions

The self-employed principal receives reimbursement from the purchaser in the form of a (non-decreasing) payment function $p(t)$ that specifies payment for each patient conditional upon the treatment intensity claimed to have been given to that patient. Auditing and verification procedures in the NHS ensure that any treatment intensity claimed is actually delivered. A principal must meet the monetary costs of treatment out of this payment and can retain any residual. In order to ensure that a patient is treated $p(t)$ must also satisfy $p(t) + b(t) - c(t) - w(\phi)\tau(t) > 0$, for some t. The principal's expected welfare, conditional upon assigning a treatment intensity of t_E^S to exempt and t_N^S to non-exempt patients, is

$$\begin{aligned} W^S &= n\left[b(t_E^S) - c(t_E^S) - w(\phi)\tau(t_E^S) + p(t_E^S)\right]\rho_E + \\ &\quad n\left[b(t_N^S) - c(t_N^S) - w(\phi)\tau(t_N^S) + p(t_N^S)\right](1-\rho_E). \end{aligned} \tag{1}$$

In choosing treatment intensities, the principal will maximise (1) subject to the constraints that treatment intensities are non-negative, that the treatment given to non-exempt patients is less than $\bar{t}_N$ and an overall time constraint,

$$T \geq n\left[\rho_E\tau(t_E^S) + (1-\rho_E)\tau(t_N^S)\right]. \tag{2}$$

Henceforth, we assume that the non-negativity constraints are satisfied. Thus, provided that the payment function $p(.)$ is such that $b(t) - c(t) - w(\phi)\tau(t) + p(t)$ is concave in t, the principal chooses treatment intensities t_E^S and t_N^S to satisfy

$$\rho_E n\left[b_t(t_E^S) - c_t(t_E^S) - (w(\phi)+\lambda^S)\tau_t(t_E^S) + p_t(t_E^S)\right] = 0 \tag{3}$$

$$\left.\begin{aligned} (1-\rho_E)n\left[b_t(t_N^S) - c_t(t_N^S) - (w(\phi)+\lambda^S)\tau_t(t_N^S) + p_t(t_N^S)\right] + \lambda_N^S &\leq 0 \\ t_N^S &\leq \bar{t}_N \end{aligned}\right\} \tag{4}$$

$$\left.\begin{aligned} n\left[\rho_E\tau_t(t_E^S) + (1-\rho_E)\tau_t(t_N^S)\right] &\leq T \\ \lambda^S &\geq 0 \end{aligned}\right\} \tag{5}$$

where λ^S is the multiplier associated with constraint (2), λ_N^S is the multiplier associated with the upper treatment constraint on non-exempt patients and a right hand brace indicates a pair of complementary inequalities, one of which must hold with equality.

An associate dentist is not a part owner of the practice but enters into an income sharing arrangement with a principal. The associate receives the same payment $p(t)$ as the principal but pays over a fraction $(1-\alpha)$ to the principal as recompense for the monetary costs associated with treatments carried out in the dental practice. The

[4]The results of our analysis are preserved if it is possible for a dentist to exert an effort to persuade a patient to accept more treatment but this effort is costly.

welfare to the associate from this arrangement conditional upon assigning treatment intensities of t_E^A, t_N^A to exempt and non-exempt patients is, therefore,

$$\begin{aligned} W^A &= n\left[b(t_E^A) - w(\phi)\tau(t_E^A) + \alpha p(t_E^A)\right]\rho_E + \\ &\quad n\left[b(t_N^A) - w(\phi)\tau(t_N^A) + \alpha p(t_N^A)\right](1-\rho_E). \end{aligned} \tag{6}$$

The constraints to be satisfied in choosing treatment intensities are the same as those described for the principal and, therefore, the associate chooses treatment intensities t_E^A, t_N^A to satisfy

$$\rho_E n\left[b_t(t_E^A) - (w(\phi)+\lambda^A)\tau_t(t_E^A) + \alpha p_t(t_E^A)\right] = 0 \tag{7}$$

$$\left.\begin{aligned} (1-\rho_E)n\left[b_t(t_N^A) - (w(\phi)+\lambda^A)\tau_t(t_N^A) + \alpha p_t(t_N^A)\right] + \lambda_N^A &\leq 0 \\ t_N^A &\leq \overline{t}_N \end{aligned}\right\} \tag{8}$$

$$\left.\begin{aligned} n\left[\rho_E\tau_t(t_E^A) + (1-\rho_E)\tau_t(t_N^A)\right] &\leq T \\ \lambda^A &\geq 0 \end{aligned}\right\} \tag{9}$$

An employed dentist receives a fixed wage W over the specified duration. There are no costs incurred other than the costs of time. The welfare to the associate from this arrangement conditional upon assigning treatment intensities of t_E^E, t_N^E to exempt and non-exempt patients is, therefore,

$$W^E = n\left[b(t_E^E) - w(\phi)\tau(t_E^E)\right]\rho_E + n\left[b(t_N^E) - w(\phi)\tau(t_N^E)\right](1-\rho_E) + W. \tag{10}$$

The constraints to be satisfied in choosing treatment intensities are the same as those described for the principal (and associate) and, therefore, the employed dentist chooses treatment intensities t_E^E, t_N^E to satisfy

$$\rho_E n\left[b_t(t_E^E) - (w(\phi)+\lambda^E)\tau_t(t_E^E)\right] = 0 \tag{11}$$

$$\left.\begin{aligned} (1-\rho_E)n\left[b_t(t_N^E) - (w(\phi)+\lambda^E)\tau_t(t_N^E)\right] + \lambda_N^E &\leq 0 \\ t_N^E &\leq \overline{t}_N \end{aligned}\right\} \tag{12}$$

$$\left.\begin{aligned} n\left[\rho_E\tau_t(t_E^E) + (1-\rho_E)\tau_t(t_N^E)\right] &\leq T \\ \lambda^E &\geq 0 \end{aligned}\right\} \tag{13}$$

3.2 Comparison of treatment intensities

Any two dentists will have different observed treatment intensities according to their valuation of time as measured through $w(\phi)$, the number of patients they have to treat and their remuneration. In our empirical study we control for variations between dentists using a fixed effects framework and thus we focus here on the roles of remuneration method and numbers of patients treated.

We consider first the effect of remuneration conditional upon n being sufficiently small and $\overline{t}_N$ being sufficiently large such that neither of the associated constraints bind on any dentist. In this case the impact of remuneration upon treatment intensities can be deduced from (3), (4), (7), (8), (11) and (12), setting all Lagrange multipliers to zero. The following proposition summarises the main results.

Proposition 1 *When neither time constraint nor treatment constraints bind then given any remuneration contract, (1) a dentist will choose the same treatment intensities for their exempt and their non-exempt patients, however, (2) a self-employed associate will treat both exempt and non-exempt patients more intensively than an employed dentist and (3) a self-employed principal will treat patients more intensively than an employed dentist provided that* $p_t - c_t > 0$. *Hence,* $t_E^A = t_N^A > t_E^E = t_N^E$ *and if* $p_t - c_t > 0$ *then* $t_E^S = t_N^S > t_E^E = t_N^E$.

Proof. If $\lambda^S = \lambda_N^S = 0$ then condition (3) is equivalent to (4) and the choice of treatment intensity for non-exempt patients is the same as the choice of treatment intensity for exempt patients. Similarly for the coices of associate and employed dentists when $\lambda^A = \lambda_N^A = 0$ and $\lambda^E = \lambda_N^E = 0$ respectively, thus establishing 1. Setting $\lambda_N^A = \lambda_N^E = 0$ and comparing (8) with (12) it follows that $t_N^A > t_N^E$. Combining this observation with the already established claim 1. establishes claim 2. Finally, setting $\lambda_N^A = \lambda_N^E = 0$, assuming that $p_t - c_t > 0$ and comparing (4) with (12) it follows that $t_N^S > t_N^E$. Combining this observation with the already established claim 1. establishes claim 3. ■

The benchmark case of non-binding constraints establishes that dentists who are remunerated in relation to the treatment that they carry out (self- employed principals and associates) will engage in more intensive treatment. The requirement for the marginal price of treatment to exceed the marginal monetary cost of treatment ($p_t - c_t > 0$) is one we expect to be satisfied in practice because, as discussed in section 2 above, treatment prices in the NHS are set so as to cover both the monetary and time costs of treatment. Provided this condition is satisfied, there is a close analogy between principal and associate dentists in terms of the theory of incentives – both are remunerated over and above their respective altruistic benefit $b(.)$ for more intensive treatments. Henceforth, in this section we assume that $p_t - c_t > 0$ and simply refer to *self-employed dentists* in place of the associate and principal. Whilst qualitatively the two forms of self-employed remuneration are similar, there is the possibility that they will lead to different treatment intensities — a possibility that we allow for in the empirical analysis that follows.

Proposition 1 establishes a reference point which suggests that exempt and non-exempt patients will be treated equally *within* a remuneration structure but differentially *across* remuneration structures. However, constraints will in practice bind for at least some types of dentist. In particular, since more intensive treatments are costly in terms of time, it is more likely that a self-employed dentist will be time constrained. Furthermore, since a self-employed dentist will wish to increase treatment intensity, they are more likely to encounter resistance from patients, captured in the model by the possibility of a binding treatment constraint. In either case corresponding Lagrange multipliers are non-zero and the claimed relationship between treatment intensities can fail. However, in both cases it is self-employed dentists who, on account of their desire to increase treatment intensity, will first encounter a binding constraint. We therefore consider next the case of a time constraint binding on self-employed dentists.

Proposition 2 *When the treatment constraint does not bind and the time constraint*

binds on only self-employed dentists then both employed and self-employed dentists will choose the same treatment intensities for exempt and non-exempt patients and a self-employed dentist will treat patients more intensively than an employed dentist Hence, $t_E^A = t_N^A > t_E^E = t_N^E$ *and* $t_E^S = t_N^S > t_E^E = t_N^E$.

Proof. According to the conditions of the proposition, $\lambda_N^S = \lambda_N^A = \lambda_N^E = \lambda^E = 0$ and $\lambda^S, \lambda^A > 0$ and the demonstration of the proposition follows that for Proposition 1. ■

Whilst the existence of a time constraint reduces the treatment intensities offered by self-employed dentists it does not impact upon the relative treatment offered to exempt and non-exempt patients. However, when the treatment constraint binds on a self-employed dentist it impacts on the treatment that can be administered to non-exempt patients – exempt patients who are insulated from the cost of their treatment will be more accepting of more intensive treatment. Thus, in the case of a binding treatment constraint there is a rationale for a self-employed dentist to treat exempt and non-exempt patients differently. The following proposition provides the details.

Proposition 3 *When the time constraint does not bind and the treatment constraint binds on only self-employed dentists, then self employed dentists will treat exempt patients more intensively than non-exempt patients whilst employed dentists will treat exempt and non-exempt patients with equal intensity. Hence,* $t_E^A > t_N^A > t_E^E = t_N^E$ *and* $t_E^S > t_N^S > t_E^E = t_N^E$.

Proof. Under the conditions stated in the proposition $\lambda^S = \lambda^A = \lambda^E = \lambda_N^E = 0$ and $0 < \lambda_N^A, \lambda_N^S$. It follows from comparing condition (3) with (4) and (7) with (8) that both kinds of self-employed dentists will set higher treatment intensities for exempt patients. The comparison of (11) with (12) confirms that the employed dentist will treat exempt and non-exempt patients equally (as in Proposition 1). Furthermore, as in Proposition 1 inspection of the first order conditions (3),(7) and (11) establishes that a self-employed dentist will engage in more intensive treatments than their employed counterparts. ■

Proposition 3 provides insight into why treatment intensities to exempt and non-exempt patients might vary according to a dentist's remuneration. If a dentist has a financial interest in increasing the intensity of treatment, and if such an increase is easier to effect on some patients than on others, then otherwise identical patients may receive differing treatment. Since in our framework it is self-employed dentists that have a financial interest in treatment intensity, it is these dentists that we should expect to see offering different treatment intensities across exempt and non-exempt patients. Employed dentists have no incentive to discriminate in this way. According to Proposition 3 a self-employed dentist will continue to treat both exempt and non-exempt patients more intensively than their employed counterpart. However, when both the time constraint and the treatment constraint bind on a self-employed dentist the incentive to increase treatment intensity on those patients for whom such an increase is possible can result in a reduction of treatment intensity for other patients. The following proposition provides the details.

Proposition 4 *When both the time constraint and the treatment constraint bind on only self-employed dentists, then, 1. self-employed dentists will treat exempt patients more intensively than non-exempt patients whilst employed dentists will treat exempt and non-exempt patients with equal intensity and 2. self-employed dentists will treat exempt patients more intensively than employed dentists but may treat non-exempt patients less intensively than employed dentists. Hence,* $t_E^A > t_E^E = t_N^E \lessgtr t_N^A$ *and* $t_E^S > t_E^E = t_N^E \lessgtr t_N^S$.

Proof. Under the conditions stated in the proposition $\lambda^E = \lambda_N^E = 0$ and $0 < \lambda_N^A, \lambda_N^S, \lambda^S, \lambda^A$. It follows from comparing condition (3) with (4) and (7) with (8) that both kinds of self-employed dentists will set higher treatment intensities for exempt patients. The comparison of (11) with (12) confirms that the employed dentist will treat exempt and non-exempt patients equally. Inspection of the first order conditions (4),(8) and (12) given that $\lambda^A, \lambda^S > \lambda^E = 0$ admits the possibility that an employed dentist will engage in more intensive treatments of non-exempt patients than their self-employed counterparts. ■

Finally in this section, we address the issue of the tightening of a dentist's time constraint. Whilst the time that a dentist has available is not something we expect to observe variations in, different dentists face varying patient caseloads. An increasing caseload implies that the time available to treat any one patient is reduced, with consequences for the treatment intensity that can be delivered. The following proposition provides details of this.

Proposition 5 *If the time constraint is strictly binding for both self-employed and employed dentists and the treatment constraint is not binding on any dentist then* $\frac{dt_E^S}{dn}, \frac{dt_N^S}{dn} < 0, \frac{dt_E^A}{dn}, \frac{dt_N^A}{dn} < 0$ *and* $\frac{dt_E^E}{dn}, \frac{dt_N^E}{dn} < 0$. *If the time constraint is not binding for either self-employed or employed dentists and the treatment constraint is binding on only self-employed dentists then* $\frac{dt_E^S}{dn} = 0, \frac{dt_N^S}{dn} < 0, \frac{dt_E^A}{dn} = 0, \frac{dt_N^A}{dn} < 0$ *and* $\frac{dt_E^E}{dn} = \frac{dt_N^E}{dn} = 0$.

Proof. By inspection of conditions (3), (4),(7) ,(11) and (12) the respective treatment intensities are decreasing in n and λ^S, λ^A and λ^E respectively, thus establishing the first part of the claim claim. Under the conditions of the second part of the claim, $\lambda^A = \lambda^S = \lambda E = 0$ and $\lambda_N^S, \lambda_N^A > 0$. Inspection of conditions (3),(establishes these are independent of n whilst conditions (4) and (7) indicate that the assoicated treatment intensities are decreasing in n. ■

Together Propositions 1 to 5 provide testable hypotheses for our empirical analysis. In summary these are: self-employed dentists should treat at least some patients more intensively than their employed counterparts; only self-employed dentists should be observed to treat otherwise similar exempt and non-exempt patients with different treatment intensities; when a self-employed dentist treats otherwise similar exempt and non-exempt patients differently, it is exempt patients who should be treated more intensively; all dentists should exhibit treatment intensities that are non-increasing in the number of patients treated.

4 Empirical Framework

4.1 Data

The details of all NHS dental treatment in Scotland are collected by the Management Information and Dental Accounting System (MIDAS) which is an administrative database primarily used for paying dentists. MIDAS covers all NHS courses of dental treatment delivered and paid for over the last 10 years – in 2000-2001 approximately 4.1 million courses of NHS dental treatment were provided. Each practice, dentist, patient, course of treatment and individual treatment is allocated a unique identifier and it is, therefore, possible to follow patients, dentists and types of treatment over time. For the purposes of our analysis we obtained a simple random sample from the MIDAS database. Specifically, our data is for the claims made in 2000-2001 for patients whose identification number ended in the digits 001 for self-employed dentists and 001, 002 or 003 for employed dentists.

When faced with a patient, a dentist designs a treatment plan detailing the treatment required to address that patient's specific dental condition. Within MIDAS this treatment plan is termed a *claim*. Within each claim the patient may receive a number of specific treatments: an examination, a scale and polish, a radiograph, an extraction etc. Each of these *claim treatments* has a specific code (and fee) associated with it. These fees are determined annually in a bilateral bargain between dentists' representatives and health boards and the menu of fees is set out in an annual publication termed the *Statement of Dental Remuneration* (SDR). Whilst the level of fees has increased over time, the relative fees for treatments have remained fixed and based on the initial timings referred to in Section 2. Hence, the total value of a claim is the empirical analogue of $p(t)$ and provides an indication of the time that the dentist has spent treating a patient. Henceforth, we use the log of the real fee claimed[5] to measure the intensity of treatment t.

Our data set contains 14053 usable claims and we further restrict the sample to include only those courses of treatment that require some active intervention by a dentist (approximately 75% of the full sample). This involves removing claims where the only treatments are, either alone or in conjunction, a dental examination and a scale and polish. These limited treatments are only provided when the patient is in a good state of dental health and requires no active treatment[6]. Following removal of these claims, there are 821, 1769 and 7299, active claims for treatment provided by employed, associate and principal dentists respectively. These relativities accord well with the reported data on the proportion of associate, principal and employed GDPs in Scotland (Dental Business Trends Survey, 2000). Table 1 provides descriptive statistics of these data.

The variables in Table 1 can be related to the theoretical model of Section 3 directly or indirectly. The variable *clpery* is the empirical counterpart of n, the number of claims per time period. The number of of claims per dentists is much larger for em-

[5] Adjusted to prices in 1999-2000

[6] In subsequent empirical analyses we intend to model these minimum treatment cliams more formally.

Table 1: Descriptive statistics by contract

Variable	Description	Principal	Associate	Employed
n	Total number of claims	7299	1769	821
lrf	The log of the real fee per claim	3.43	3.37	3.43
$clpery$	The number of claims per dentist per year	4.09	3.53	5.79
$ddiag$	Equals 1 if at least one treatment on the claim was a diagnosis item	0.62	0.59	0.67
$dprev$	Equals 1 if at least one treatment on the claim was a preventive item	0.0001	0.003	0
$dperio$	Equals 1 if at least one treatment on the claim was a periodontal item	0.40	0.35	0.35
$dcons$	Equals 1 if at least one treatment on the claim was a conservative item	0.63	0.61	0.55
$dsurg$	Equals 1 if at least one treatment on the claim was a surgical item	0.15	0.15	0.23
$dprosth$	Equals 1 if at least one treatment on the claim was a prosthetic item	0.12	0.11	0.13
$dorth$	Equals 1 if at least one treatment on the claim was an orthodontic item	0.03	0.02	0
$dother$	Equals 1 if at least one treatment on the claim was an 'other' item	0.16	0.19	0.19
$page$	The age of the patient	37.68	36.10	39.44
$dpsex$	The sex of the patient	0.44	0.49	0.47
$depcat$	The deprivation category of the dentist's practice	3.99	3.79	3.90
$exempt$	A dummy varible equal to 1 if the patient is exempt	0.37	0.35	0.34

Note: The 'other' claims constitute miscellaneous treatments not categorised elsewhere.

ployed dentists than self-employed dentists because – given that employed dentists are approximately 2% of the Scottish dental workforce – we sampled more patients from employed dentists. Whilst our theoretical model considered a single type of dental condition, it is straightforward to generalise it to a multiple or a continuum of dental conditions. The dummy variables $ddiag, dprev, dperio, dcons, dsurg, dprosth, dorth$ and $dother$ are based on the broad treatment categories defined in the SDR and thus identify different types of dental condition. For example, $dcons$ is a dummy variable which equals 1 if the patient received any type of conservative treatment and 0 otherwise. Table 1 indicates that employed dentists provide more surgical treatment and less conservative treatment than their self-employed counterparts. Besides dental specific characteristics, we use standard patient characteristics (age, sex and the socioeconomic indicator $depcat$) as further proxies for different types of patients. Finally, the exemption status of the patient $exempt$ indicates whether a patient is insulated from charges and is the exact analogue of the exempt category of patients discussed in section 3. Approximately 65% of claims in the sample were made in respect of patients who were liable for the full NHS patient charge which constitutes 80% of the NHS treatment fee. Patients may be exempt from payment of NHS dental charges for a number of reasons depending upon their individual circumstances including age, employment/income status or general health (e.g. pregnant and nursing mothers are exempt).

4.2 Regression results

Our objective is to determine the impact of remuneration on treatment decisions but as the theoretical model makes clear treatment decisions are a consequence of both the remuneration method and unobservable variations (ϕ) between dentists. Furthermore, dentists may choose the form of remuneration that is most advantageous to them and thus the observed treatment intensities will exhibit selection bias. To deal with these issues we adopt a fixed effects framework and estimate the fixed-effects regressions,

$$\ln y_{ij}^k = \mu^k + \alpha_i^k + x_{ij}\beta^k + \epsilon_{ij}^k, \tag{14}$$

where y_{ij}^k log real fee (treatment intensity) of claim j performed by dentist i subject to remuneration $k \in \{S, A, E\}$.The vector x includes our measures of patient types, the number of treatments carried out and the exemption status of the patient undergoing treatment.

The regression results for each of the three forms of remuneration are reported in Table 2.

Given that, at least within the data we consider, dentists work under only remuneration method the estimates reported in Table 2 represent selection-corrected estimates.

Treatment intensity is increasing, but at a diminishing rate, with patient age until patients are approximately 50 years old. Beyond age 50, treatment intensity falls. The estimates suggest that the gender of the patient is unrelated to intensity. Other controls (omitted from Table 2 for reasons of clarity) for changes in the nominal fees

Table 2: Fixed effects regression results by contract

	Principal		Associate		Employed	
	Coef.	SE	Coef.	SE	Coef.	SE
page	0.0236	0.0023	0.021	0.005	0.0218	0.0058
*page*2	-0.0002	0.0000	-0.0002	0.00006	-0.0002	0.00006
dpsex	0.017	0.023	-0.009	0.056	-0.0033	0.053
trauma	0.325	0.066	0.401	0.134	0.442	0.214
dcons	0.897	0.025	1.014	0.054	0.991	0.066
dsurg	0.519	0.03	0.524	0.064	0.344	0.075
dprosth	1.130	0.037	1.256	0.083	1.505	0.0896
dorth	1.704	0.102	1.386	0.252	(dropped)	
dother	0.193	0.031	0.215	0.063	-0.143	0.08
exempt	0.248	0.025	0.163	0.056	0.087	0.06
lcldcy	-0.111	0.025	-0.054	0.054	-0.081	0.038
cons	2.59	0.126	2.45	0.277	2.35	0.23
ρ	0.320		0.366		0.21	
R^2	0.3148		0.3209		0.3732	
Observations	7299		1769		821	

Note: these estimates are for the active group only.

for treatment were similar across self-employed dentists (and significant for principals) but not significant for employed dentists.

Variations in the patient types are captured by dummy variables representing broad SDR categories. The controls for patient types are generally significant and illustrate some differences between self-employed and employed dentists. The coefficient of *dsurg* is 0.519 for self-employed dentists and 0.34 for employed dentists which implies that patients who receive any surgical treatment receive 18% more treatment from a self-employed dentist than from an employed dentist. Combining the results of Table 1 and Table 2 implies that while self-employed dentists provide surgical treatment less frequently than employed dentists, when they do they provide that treatment more intensively. In contrast, employed dentists treat patients who require any prosthetic treatment, *dprosth*, 38% more intensively than self-employed principals.

Our theoretical framework requires that if the number of patients treated increases the probability of a dentist's time constraint binding, it should not increase treatment intensity. Our estimates suggest that the elasticity of the intensity of treatment per claim (with respect to the number of claims) is approximately -0.05 for associates, -0.11 for principals and -0.08 for employed dentists. While the elasticity is significant at the 5% level for both self-employed principals and employed dentists, the elasticity is not significant for associates.

An exempt patient receives approximately 25% more intensive treatment than a patient liable for the full NHS dental charge if treated by a principal and 16% more intensive treatment if treated by an associate. Thus, *ceteris paribus*, we find evidence of a distinction between principals and associates in the intensity with which they treat exempt versus non-exempt patients. The coefficient on the *exempt* term

suggests that associates and principals respond to the exemption status of the patient in significantly different ways. Other things equal, principals are more responsive to the exemption status of the patient than associates: relative to a non-exempt patient, principals treat exempt patients approximately 9% more intensively than associates. In contrast there is no significant effect of exemption status on treatment intensity for employed dentists.

The distinct estimates for both principals versus associates and self-employed versus employed dentists are consistent with our theoretical predictions. First, the distinction between employed and self-employed dentists is consistent with both the demand and time constraint binding for self employed principals and only the time constraint binding for employed dentists. Second, the distinct and significant estimates for principals and associates are consistent with the time and demand constraint binding for both types of self-employed dentist but, given their revenue sharing arrangements with the principal, the incentives to increase intensity are mitigated for associates.

5 Discussion

It is commonplace for economists to predict that self-interested clinicians will deliver treatments that are influenced by the financial rewards that they are offered. In contrast, physicians are inclined to claim that professional ethics operate to ensure that it is patients' interests alone that determine treatments. Evidence relevant to adjudicating between these views is difficult to acquire and interpret because, whilst it is possible to observe different patterns of treatment that correlate with different remuneration structures, there are many factors that could account for such differences. For example, patients with particular medical conditions might be drawn towards the particular type of physician who happens to work under a particular form of remuneration, or physicians may exhibit genuinely held differences in what constitutes the patient's best interest and may choose the form of remuneration structure to work under accordingly. Both variations in patients' underlying medical conditions and differences in clinical opinion are arguably justifiable sources of variation in observed treatment and disentangling the pure effect of remuneration from amongst these confounding influences is problematic.

The data that we have had access to, and which concern the delivery of dental treatments under the NHS in Scotland, provide a means of resolving these issues because we can observe dentists making choices over a large number of patients, many of whose characteristics we can observe. Hence, a fixed effects regression framework, in which dentist specific preferences are controlled for and in which proxies for patient types are used to control for the allocation of different types of patients to dentists who are subject to differing remuneration methods, permits us to consider the effect of remuneration alone on treatment decisions. In order to interpret the empirical evidence we have contructed a model in which the impact of remuneration structure works through the exemption status of patients. Interpreted in the context of this model, the empirical evidence that we have presented comes down in favour of the

economist's view – once the other confounding influences have been accounted for, remuneration exerts an impact on treatment choices and does so in a way that accords well with the economic model. Where patients can be expected to exert little influence over their treatment because they are insulated from the cost, we expected to find treatment being increased and that expectation is borne out by the data. In the context of the dental treatment of patients who are exempt from charges in the NHS we find that self-employed dentists provide 15-20% (by value) more treatment. The more the dentist has a financial stake in the treatment offered — as is probably the case for the owners of dental practices — the greater is the effect. Overall, treatment intensity across all patients is approximately equal between self-employed and employed dentists indicating that there is a significant distributional impact of the treatment decisions that we have analysed. Non-exempt patients receive less treatment from self-employed dentists than from employed dentists, indicating that the overall time available to carry out more intensive treatments is limited and that extra treatment for some is less treatment for others.

One key policy conclusion of our analysis is, therefore, that remuneration matters — it has real effects on the treatments that are delivered. Where policy makers are concerned that treatment should reflect either the requirement of patients or the assessments of physicians, it is important to choose the appropriate remuneration method. Our analysis has not dealt with the obvious question of which remuneration method is to be preferred because in order to answer that question we would need much more information on the costs and benefits of dental care. Nevertheless, equipped with evidence to support the view that the choice of remuneration method can be influential in determining clinical outcomes, the value of acquiring that information is clearer.

A second key policy conclusion of our analysis is that in the context of dentistry in the NHS, self-employed dentistry is, at least for some patients, more interventionist dentistry and an obvious concern is whether that increased intervention is justifiable in terms of clinical outcome. Even outside of the NHS, our findings have policy relevance in that there are concerns regarding the operation of the market for private dentistry in the UK — OFT (2003). If imperfections in the market for private health care result in excessive prices for treatments then our analysis indicates that those inflated prices can feed through into greater dental intervention if, as is the case with private insurance, individuals are insulated from the costs of the treatments they receive.

The theoretical framework we have used in this paper does not include unverifiable quality decisions on the part of providers. Quality of service is a key concern of policy makers and has been the subject of attention of much of the theoretical literature in health contracting. That literature suggests that the nature of the remuneration arrangement may have an important part to play in influencing quality choices by providers if there is a mechanism by which – to use our terminology – treatment intensity feeds into the marginal revenue effect of changes in quality. Again theory alone cannot resolve the question of whether quality will be adversely affected by a shift towards lower (or higher) treatment intensity and this is a important issue for future empirical research.

Whilst our data and thus the analysis have concerned the provision of dental services in Scotland, our methodology could be applied wherever there are suitable data detailing the treatments delivered under a variety of remuneration methods. This study gives some support to those who hold that financial incentives may be important tools in influencing the outcome of health care markets.

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